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Briefing Report to the Chairman
Committee on Armed Services,
House of Representatives

February 1986

MISSILE DEVELOPMENT

Status of Advanced Medium Range Air-To-Air Missile (AMRAAM) Certification

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United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-221734 February 18, 1986

The Honorable Les Aspin
Chairman, Committee on
Armed Services
House of Representatives

Dear Mr. Chairman:

This briefing report is in response to your December 1985 request for an interim report on the development status of the Advanced Medium Range Air-to-Air Missile (AMRAAM), particularly as it relates to the certification requirements contained in the Defense Authorization Act, 1986. As you know, the act requires the Secretary of Defense to certify by March 1, 1986, that (1) the AMRAAM design is complete, (2) system performance has not been degraded from the original development specification, (3) the maximum practical number of cost reduction design changes have been incorporated into the flight test program and qualified before production, (4) a fixed price contract not to exceed $556,580,480 has been entered into for research, development, test, and evaluation, (5) total production cost, for a minimum 17,000 missiles, will not exceed $5.2 billion in fiscal year 1984 dollars, and (6) the missiles procured will perform in accordance with the development specification. If certification is not made, the act states that the AMRAAM program shall be terminated.

To determine the overall program status, we met with and obtained data from Air Force officials in Washington, D.C., and the AMRAAM Joint System Project Office (JSPO) at Eglin Air Force Base, Florida. We also visited and obtained data from the AMRAAM development contractor--Hughes Aircraft Company at Canoga Park, California, and Tucson, Arizona and the second source contractor--Raytheon Company at Bedford, Massachusetts. We conducted our work from November 1985 through January 1986.

As agreed with your office, we did not request official agency comments on this report. However, the views of Air Force, JSPO, and contractor officials were obtained and incorporated where appropriate.

A summary of our observations on the status of each certification requirement follows.

DESIGN COMPLETION

The AMRAAM program manager and Air Force officials state that AMRAAM's design is essentially complete based on the Critical Design Review held

between November 1984 and February 1985. A number of design modifications have occurred since that review. Hughes' officials state the design is complete, but acknowledge that design modifications will be made as the AMRAAM program proceeds through the test and evaluation phase. Additional design changes are planned to reduce AMRAAM production costs.

PERFORMANCE DEGRADATION

The early flight test missiles have had a number of deviations from the contract specifications which, if not corrected, could impair missile performance. JSPO and Air Force officials state that these deviations are temporary and/or minor and acceptable.

COST REDUCTION CHANGES

Most AMRAAM design changes to reduce production costs are scheduled to be incorporated in production lots #3 and #4 in 1989 and 1990, respectively. JSPO states that significant cost reduction design changes will be flight tested over the next several years.

FULL SCALE DEVELOPMENT CEILING OF $556.6 MILLION

Prior to November 1985, recorded obligations under the Hughes fixed-price contract for AMRAAM full-scale development totaled approximately $556.8 million. However, when the Defense Authorization Act, 1986, was passed in November 1985, it placed a $556,580,480 ceiling on the development cost. Subsequently, JSPO negotiated contract changes to reduce recorded obligations below the ceiling. The AMRAAM Program Manager believes the ceiling may restrain AMRAAM development.

PRODUCTION CEILING OF $5.2 BILLION

Estimated production cost of $5.2 billion, in fiscal year 1984 dollars, for 17,000 missiles for the Air Force over the next 10 years is based on a number of assumptions which cumulatively reduce confidence in the estimate.

MISSILE PERFORMANCE

Assessment of the missile's performance is limited at this time because few missiles have been produced and launch tested. As of January 1986, approximately 20 full scale development missiles had been delivered to various test facilities. About half of these have been returned to Hughes because of some malfunction. Four test missiles have been air launched.

The JSPO stated that all four of these tests were successful. A fifth air launch test on January 29, 1986 was aborted when the missile failed to launch. Current plans show that many additional launch tests are to be made by 1988. By then, these tests may have determined the ability

of the missile to perform in accordance with the development specifications.

These issues are discussed in more detail in the enclosed appendixes.

As agreed with your staff, we plan no further distribution of this report until one day after its issue date. At that time, we will send copies to the Senate Committee on Armed Services, the Secretary of Defense, and to other interested parties.

Sincerely yours,

for Frank C. Conahan
Director

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OBSERVATIONS ON THE STATUS OF AMRAAM

CERTIFICATION ISSUES

BACKGROUND

The Advanced Medium Range Air-to-Air Missile (AMRAAM) is being developed jointly by the Air Force and Navy to meet their air-to-air missile requirements for the 1985-2005 time frame. The missile is to be compatible with the services' latest fighter aircraft. As a follow-on to the Sparrow medium-range air-to-air missile, AMRAAM is intended to improve interceptor combat effectiveness.

AMRAAM is to operate both within and beyond visual range. Performance features that are to provide improvement include higher speed, greater range, increased maneuverability, all aspect look-down shoot-down capability, better resistance to electronic countermeasures and an active terminal seeker. The active seeker and a track-while-scan radar aboard an aircraft provide the capability to simultaneously track multiple targets, launch multiple missiles and leave. The missile is also intended to be more reliable and maintainable.

The AMRAAM development program includes the missile, launchers, aircraft interfaces, support equipment and aircraft modifications for AMRAAM testing. Modifications to operational aircraft and eject launchers are to be developed and procured by the appropriate aircraft program offices. These offices will also procure the launchers.

The program is in full-scale development under a contract with Hughes Aircraft Company. Raytheon Company is being qualified as a follow-on second source producer for future competition.

JSPO procurement cost estimates have risen from about $10.4 billion in then year dollars for 24,335 missiles in November 1982, about $428,000 per missile, to $11.7 billion in December 1984, about $479,000 per missile. An Independent Cost Analysis made in December 1984 for the Air Force's 17,123 missiles projected a then year cost of about $490,000 per missile.

In fiscal year 1985 the Secretary of Defense expressed concern over the program's progress and escalating costs and ordered a complete review of the program to determine if and how program costs could be controlled. This review resulted in the program being restructured to stretch the missile's full scale development phase from 54 to 79 months and delay deployment from 1986 to 1989. To reduce program costs, a number of design and other changes were identified that could reduce manufacturing

and production costs by an estimated $1.7 billion for the combined Air Force and Navy buy. This reduced JSPO's estimate for 24,335 missiles to $10.6 billion in then year dollars or $435,000 per missile. This latter estimate correlates to the $5.2 billion, in 1984 dollars, stated in the Defense Authorization Act, 1986 for 17,123 Air Force missiles. Included in the reduced estimate is an additional $330 million, in then year dollars, to make the cost reduction changes.

This report addresses the AMRAAM's status as it relates to each of the certification requirements contained in the Defense Authorization Act, 1986. It does not address the need for AMRAAM, its performance requirements, effectiveness, or affordability.

DESIGN COMPLETION

The AMRAAM Program Manager and Air Force officials stated that the AMRAAM design is complete for purposes of meeting performance requirements, even though many live launch tests have not been made. Their views are based on the degree of design documentation, the degree to which the design exists in hardware, and the completion of the Critical Design Review. The Review, which was performed from November 1984 to February 1985, was made to determine, among other things, if the detail design satisfies the performance and engineering requirements. Contractor follow-on actions to satisfy outstanding Review issues took place during the remainder of 1985.

According to an Air Force official, the missile's basic design will not change unless the threat changes. The official did say, however, that there will be design modifications to reduce costs, but these changes will not affect performance. The official also stated that some minor redesigning may result from AMRAAM testing and production.

Hughes, the development contractor, stated that the design is complete. Raytheon, the second source contractor, believes the design is essentially complete. They acknowledge that as part of the full scale development phase, there will be design modifications resulting from development tests and evaluations and from manufacturing considerations.

DOD Directive 5000.3 states that development tests and evaluations are made to assist the engineering design and development process and to verify attainment of technical performance specifications. Operational tests and evaluations are conducted by the systems' users to determine, among other things, if modifications are needed.

As of January 1, 1986, Hughes had built and delivered for testing 20 of a planned 122 developmental missiles required

under the full-scale development contract. These missiles are being used in a variety of scheduled tests. Four have been air launched and three of these were fired at targets. JSPO considers these test firings successful. A fifth test firing was aborted on January 29, 1986 when the missile did not launch. The cause of the malfunction is unknown at this time. Appendix II shows a listing of missiles produced and their test purposes.

Remaining design issues

As of January 1986, certain items have not been completed nor were they scheduled to be by this time. These include software tapes, which program and direct the missile based on given tactical situations, and proposed modifications to certain components to reduce costs. We also observed some difficulties in manufacturing the initial development missiles.

Software tapes

Four of five software tapes have been designed and three have been integrated into the initial missiles. The full capabilities of the AMRAAM cannot be tested until all of the tapes are designed and integrated. Missile capabilities provided by the addition of the second tape include a data link from the aircraft to the missile, look-down shoot-down features, software for fuzing, built-in-test information and high-pulse-repetition frequencies, to obtain more and better target information. Tape three adds features such as multiple target tracking, initial electronic counter counter-measures and solutions to some targeting problems. The fourth and fifth tapes with more sophisticated electronic counter counter-measures are scheduled to be integrated in July 1986 and the spring of 1987. JSPO states that with the successful integration of the fourth tape, the AMRAAM will meet all its performance requirements.

Guidance components

Following the Critical Design Review and several air launch tests, the Seeker Servo unit, which drives the missile's antenna, was modified in the earlier built missiles as well as in the current ones. Also, the Radar Frequency Processor's design was modified. JSPO stated that the need for these changes were identified prior to the Critical Design Review.

Cost reduction design changes

Hughes and Raytheon have submitted proposals to JSPO to modify certain missile components and subcomponents to make the missile less costly to produce. Negotiations are underway between the JSPO and the contractors on some of the proposals.

JSPO estimated that it will take two years to design and qualify the proposed cost reduction changes and about another year will be required to fabricate and integrate the changes into the manufacturing process.

Manufacturing difficulties

At the Hughes facilities, we found that certain guidance system components were presenting manufacturing difficulties. For example, there have been difficulties in manufacturing the Receiver/Range Correlator. Hughes has retained the Correlator and the Electronic Unit's Input/Output section at its research and development facility at Canoga Park, California, while other guidance and control components have been transferred to the production plant in Tucson, Arizona, for assembly or manufacture. Hughes officials commented that these complex units were retained because of limitations in the learning rate, manufacturing capacity and workload at the Tucson plant.

PERFORMANCE DEGRADATION

Although the missile components and subcomponents have been designed to meet certain contract specifications, a number of deviations in the test missiles were found. These deviations, if not fixed, could impair missile performance. Both JSPO and the contractor consider these deviations temporary and/or minor and acceptable. The number of deviations has diminished as additional work and testing has progressed.

The deviations involved the radar, launch time, guard antenna, and the physical environment. They include:

--A problem with the radar receiver protection device. This problem, if not corrected, would adversely affect the missiles' acquisition range. (The JSPO Program Manager said design solutions have been undertaken and the modifications will be flight tested in November 1986).

--Increase in launch sequence time, which would increase the time between firings up to half second. (The Program Manager stated an engineering change is planned to relax the requirement.)

--Guard antenna capability does not meet its specifications at extreme bore sight angles. (According to the contractor, this would not reduce electronic counter counter-measures' capability. The Program Manager stated that proposed design modifications will be flight tested in 1987).

--Temperature specification extremes have not been met. (JSPO will consider possible modifications or reducing the requirement.)

COST REDUCTION CHANGES

JSPO states that 10 missiles from production lot #1 will be used to incorporate and test cost reduction design changes over the next several years. Most of these changes will be incorporated into production lots #3 and #4 scheduled for 1989 and 1990 respectively.

Recently, the first increment of the contractors' cost reduction proposals were evaluated and selections were made by JSPO. The Air Force and the Department of Defense are now reviewing these with initial contract award planned in March 1986.

FULL-SCALE DEVELOPMENT CEILING OF $556.6 MILLION

Before the November 8, 1985, enactment of the Defense Authorization Act, 1986, JSPO's recordable obligations with the development contractor exceeded the act's $556.6 million ceiling by about $200,000. In December 1985, JSPO awarded a contract modification which deleted certain requirements and resulted in a downward adjustment of these obligations to comply with the March 1, 1986, certification ceiling.

The original full scale development contract was a fixed-price incentive fee contract negotiated in December 1981. The contract ceiling of $556.6 million was reached by May 31, 1985. Appendix III shows the cumulative obligations at May 31, 1985, the contract modifications made through December 1985, and the reasons for these changes.

The AMRAAM Program Manager informed us that obligations above the ceiling are needed to minimize risk. JSPO had planned to open a third test site for AMRAAM at Eglin Air Force Base and procure a third captive flight test vehicle in the latest configuration. He said these actions would also necessitate support from Hughes in order to take advantage of near-term developments. He believes that, if additional contractor funding is not authorized, flexibility in testing would be inhibited, but he emphasized such authorization is not needed for missile design purposes.

AMRAAM's total estimated development cost to the Government, as outlined in the August 1985 Office of the Secretary of Defense Program Review, was $1.35 billion. Additionally, Hughes Aircraft Company anticipates that it will absorb $255 million toward developing the AMRAAM, making the total estimated development cost $1.6 billion.

PRODUCTION CEILING OF $5.2 BILLION

The Air Force's estimated production cost of $5.2 billion in fiscal year 1984 dollars for 17,123 missiles is based on a number of assumptions. The accuracy of these assumptions is essential to the $5.2 billion estimate. Historically, similar assumptions, for other major acquisitions, have changed over time. The potential for such changes reduces confidence in the estimate being achieved. Raytheon estimated the cost for these missiles to be somewhat less than the Air Force's production estimate. JSPO stated the $5.2 billion estimate is conservative.

Some of the assumptions include:

--Joint service funding will approximate $1 billion annually, in then year dollars, over a 9 year period beginning in fiscal year 1988.

--The Navy will buy 7,212 missiles beginning in fiscal year 1989, for a total production of 24,335 missiles.

--A full production rate of 3,000 missiles annually will be maintained for 7 years beginning in fiscal year 1990. (Recent Sparrow procurement history shows that annual and total planned purchases often vary from actual purchases. However, the estimate does not include the potential for foreign military sales which could increase total production and reduce unit cost.)

--Most cost reduction design modification will be fully developed and integrated into production lots #3 and #4 in fiscal year 1989 and 1990, respectively.

--The combined Air Force/Navy buy will have design and other changes that will save $1.7 billion in then-year dollars. About $1.2 billion in savings would be applicable to the Air Force procurement. (An Air Force official stated that this is a conservative estimate and represents only 75 percent of the anticipated savings.)

--No model or major design changes will be made to the missile over the next 10 years. (The Department of Defense has already endorsed future producibility and performance improvements that emphasize technology for an advanced seeker and an advanced processor.)

--Large savings will result from competition at both the prime and subcontractor levels, beginning with production

lot #3. (JSPO currently plans to purchase lots #1 and #2, totaling over 1,000 missiles noncompetitively. This low rate production is based upon an allocation to the two contractors. The two lots represent 4.5 percent of the total production quantity and 17.9 percent of the estimated total production cost, which includes nonrecurring expenses. Also, a number of major and critical subcontractor items are now being bought noncompetitively.)

--Unit production costs will drop from about $3.1 million per missile in 1987, which includes nonrecurring start-up costs, to about $360,000 per missile, in then year dollars, in 1990. (This is based on funding, production quantity, production rate, and many other assumptions.)

MISSILE PERFORMANCE

To validate missile performance, numerous tests such as captive carry, software and hardware integration, reliability, environmental, electromagnetic and live air launched flights are underway. During the full-scale development phase, 122 test missiles are to be built and delivered by Hughes. Some of the types of tests are shown in Appendix II.

DOD officials state that 20, out of the contracted 122 missiles, have been produced and delivered to field test facilities such as the Pacific Missile Test Center, Point Mugu, California; Holloman Air Force Base, New Mexico; Raytheon Company's Bedford, Massachusetts, plant; and General Dynamics' Fort Worth, Texas, plant. About half of these missiles were returned to Hughes to correct some malfunction. Hughes analyzed the problems and modified or replaced the components or subcomponents as needed. In some cases it was found that the missile test equipment had difficulties and had to be modified. Appendix IV describes some of the significant malfunctions and the actions taken.

AMRAAM's performance specification requires a high kill probability under a variety of combat, weather, and electronic counter-measure conditions. This combat performance value--the probability of kill--differs from physical performance measurements such as weight or speed, in that it is determined analytically. The probability of kill performance criterion is determined from a series of factors that must be considered together. Examples of these are prelaunch reliability, in-flight reliability, guidance accuracy, fuze accuracy and warhead destruction capability. To attain a high confidence that these factors will achieve the desired probability of kill levels, a large number of environmental tests, ground simulations, captive flights and flight tests must be made against various types of targets.

Such a volume and variety of testing is not scheduled to be completed by March 1, 1986, to provide sufficient assurance of meeting the desired performance criteria. This is not unusual for this phase of a program. The current plan shows that by 1988, 90 flights will have been completed using four types of aircraft as part of the Development Test and Evaluations and the Initial Operating Test and Evaluations. By then, these tests may have determined the ability of the missile to achieve its required kill capability.

APPENDIX II

MISSILES PRODUCED BY HUGHES AIRCRAFT COMPANY

FOR FULL SCALE DEVELOPMENT TEST PURPOSES

AS OF DECEMBER 31, 1985

No. of Missiles	Test Program	Purpose
4	Test, Analyze and Fix	Reliability and environmental testing
2	AMRAAM Captive Equipment	Software and aircraft integration
1	Software Integration	Software development
2	Government Simulation Hardware	Performance simulation
1	Proof of Design	Engineering design checks
2	Integration Test	Aircraft integration
4	AMRAAM Air Vehicles-Instrumented	Launch flights
1	Separation/Control Vehicle	Separation and missile performance
1	HERO/Have Note	Electromagnetic environmental tests
1	Environmental Test Vehicle	Qualification test
1	Follower Missile	Follow-on contractor training
20		

MODIFICATIONS TO THE AMRAAM FULL SCALE DEVELOPMENT CONTRACT

FROM MAY 31, 1985 THROUGH DECEMBER 31, 1985

Date/and modification number	Purpose of modification	Recordable obligation amount	Total
5/31/85	-	-	$556,580,480
7/31/85 (P00071)	Preliminary design study of the metal composite for AMRAAM launchers to determine weight savings and production cost impact	$125,859	556,706,339
7/19/85 (P00072)	Additional qualification test on the Safe-Arm Firing Device	81,000	556,787,339
11/08/85 (P00073)	Adjustment to prior recordable obligation (P00072)	-8,370	556,778,969
12/20/85 (P00076)	Deletion of contractor inspection and repair as necessary of three reliability test vehicles to comply with authorizing legislation.	-411,612	556,367,357

APPENDIX IV

DESCRIPTION OF MISSILE TEST ANOMALIES AND ACTIONS TAKEN

At the Pacific Missile Test Center at Point Mugu, California, three Test Analyze and Fix missiles were tested for reliability and environmental effects. The power up sequence for one missile was incorrect resulting in failures of its electronic units' board and harness. The sequence error was caused by test set equipment problems and not with the missile itself. A second missile experienced a telemetry system failure. A third missile had a control section failure, caused by the accidental opening of the test chamber, which resulted in condensation damage to some of the missile's subcomponents. The three missiles were returned to Hughes for repair.

An Integration Test missile was sent to McDonnell Douglas and another to General Dynamics for aircraft integration tests. Both missiles experienced built-in test equipment failures. One had a telemetry unit failure and the other had a filter rectifier problem. These missiles were returned to the contractor for analyses and rework.

One missile was sent to Raytheon Company for training purposes. That missile would not power up. It was returned to Hughes for analysis. An electronic conversion unit in that missile was replaced.

The four air launched tests were considered successful by JSPO. In the first air launch, the missile had some instability in its flight. This was corrected by modifying the tape 2 autopilot software, which activates the control section before the missile leaves the aircraft. The second launch flight revealed sudden changes in terminal steering. A third showed a few terminal problems. The fourth revealed no anomalies; it knocked down the target drone.

A fifth air launch test scheduled for December 1985 was postponed until mid January 1986, because ground tests revealed a power problem with the transmitting tube's coil. The missile was returned to Hughes for further testing, evaluation, and component replacement.

The mid January test was further delayed when a replacement missile was found to have a hardware problem. This missile was returned to Hughes' Canoga Park facility for repair.

At the end of January another flight test was attempted. The missile self aborted because of internal power problems. This missile was also returned to the contractor for further analyses.

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